FOREST RESEARCH REPORT

NOVA SCOTIA DEPARTMENT OF LANDS AND FORESTS
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No. 5, March 1988

PLANTATION ASSESSMENT PRIVATE LANDS 1985

INTRODUCTION

Between 1977-84, under the federal-provincial forestry development agreements; General Development Agreement (G.D.A.) and Forest Resource Development Agreement (F.R.D.A.), over 10 million seedlings were shipped to private woodlot owners for the reforestation of cutovers, abandoned fields, and other non-regenerating or poorly stocked lands in Nova Scotia. In November 1985 a contract was awarded by public tender for the survey of selected plantations established on these woodlots.

METHODS

PLANTATION SELECTION

Selection of plantations for sampling was restricted to those established on private woodlots between 1978-1984 in each of the eight provincial subdivisions (Figure 1). The number of plantations randomly sampled in each subdivision was based on the proportion of acreage planted in the subdivision to the provincial total. A list of the selected plantations was arranged by subdivision and then forwarded to a contractor. The contractor subsequently obtained more detailed plantation records from the appropriate Nova Scotia Lands and Forests field office or Group Venture[1] office. These records were utilized to determine the location and background for each plantation sampled.

PLANTATION ASSESSMENT

The contractor established plots in each sampled plantation. They were located at predetermined, equal intervals along parallel and equally spaced cruise lines in each plantation. The cruise lines were

1. Group Ventures are incorporated woodlot owner cooperatives financed jointly by the federal- provincial forestry agreements and the members.

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drawn on plantation sketches prior to the actual assessment. Also pre-planned were the number of plots and distance between plots. The required number of plots for each plantation was based on a sampling intensity of 0.5% or a minimum number of three plots.

Each plot was subdivided into three circular subplots (except for plantations site prepared by plowing). These subplots were arranged with their centers eight metres apart along a line perpendicular to the cruise line (see Figure 2). These plantations were assumed to have been planted at a 1.8 m x 1.8 m spacing. Therefore the subplot radius was set at 2.1 m to include four possible planted trees. In some cases more than four planted trees were counted within a subplot due to uneven or inaccurate spacing. In every 9th subplot a 'study tree' was selected for height and root growth assessment. A minimum of two 'study trees' were selected per plantation.

The planted trees found in each subplot were

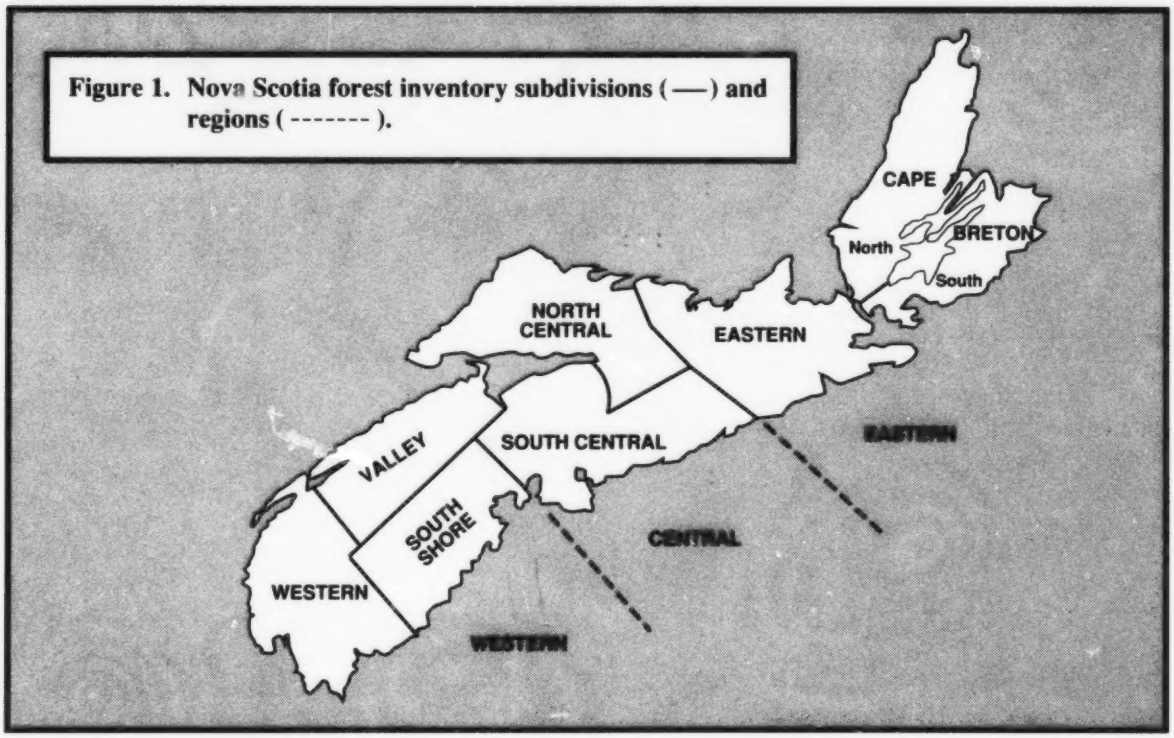

Figure 1. Nova Scotia forest inventory subdivisions (—) and regions (-------).

categorized as healthy, unhealthy or dead. They were also assessed for browsing. If a tree was not found at a plantable microsite, it was tallied as missing. A non-plantable area referred to any microsite within the subplot which could not have been planted due to heavy brush, thick duff, rock outcrop, stones, boulders, wetness, etc. Natural softwood regeneration was tallied up to a maximum of four per subplot.

Plantations that were site prepared by plowing were sampled with line plots. These plots were 16.5 metres in length to include ten possible planted trees at 1.8 m x 1.8 m spacing. Again more than the expected ten trees could occur in these plots due to uneven or short spacing.

The vegetative competition for each planted tree was noted as either light, moderate or severe, when present. Competition was also assessed for the plantation as a whole. The species, cover and height of this overall competition was recorded only if it was judged as most likely to affect the survival and growth of the planted stock at that site.

The percentage stocking for plantations was determined for a) planted trees to total area (PTA), b) planted trees to plantable area (PPA), c) natural regeneration to total area (NAT), and d) planted trees plus natural regeneration to total area (PLN)[1].

Further information on the plantation assessment methodology can be obtained from the Department of Lands and Forests.

1. Natural seedlings were counted in calculating PLN only if the subplot was under-stocked with planted seedlings and only to bring the total stocking (PLN) to a maximum of 100% for each such subplot.

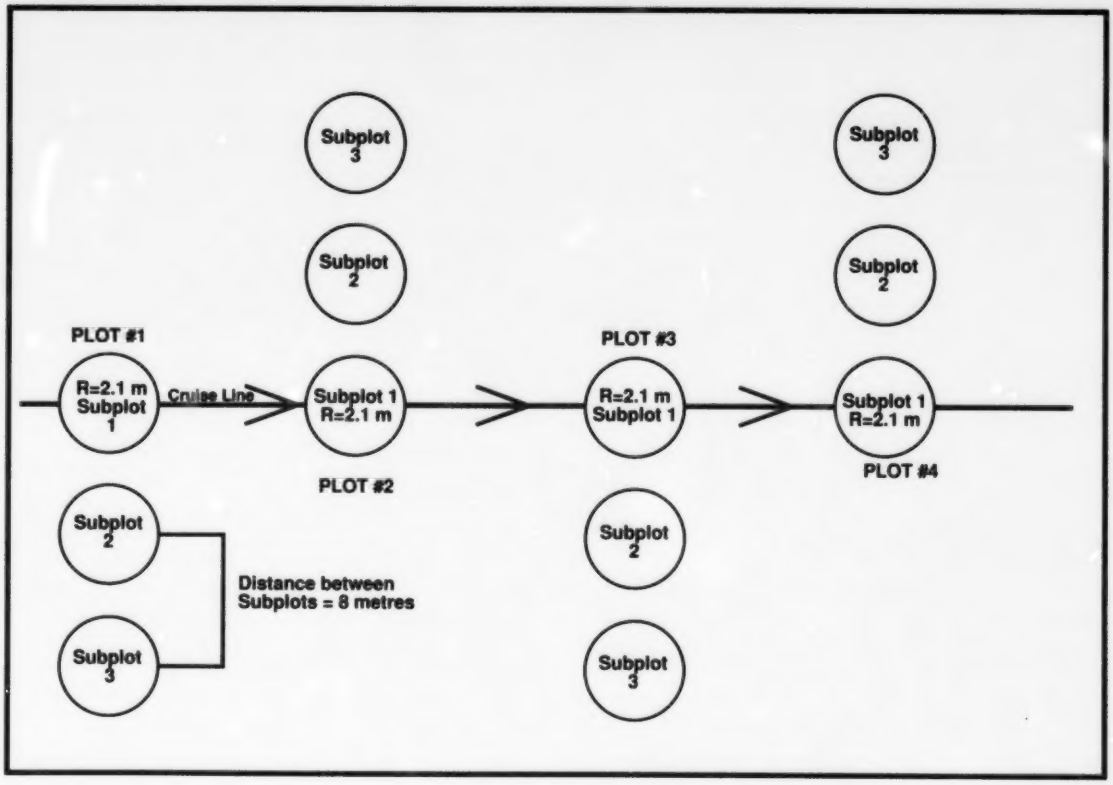

Figure 2. The circular plot system used to assess plantations on non-plowed areas. Plots were located perpendicular to the cruise lines and alternated on either side of the cruise line.

RESULTS AND DISCUSSION

PLANTATION SAMPLING

The plantation assessment started on November 25, 1985 and was completed by the end of January, 1986. The contractor was supplied with a listing of 288 possible plantations for assessment. Of this total, 248 plantations were assessed representing an area of 842 hectares. However, 34 of these plantations (5% by area) were discarded for the following reasons:

spot planting	14	understory planting	2
unknown location	5	cattle grazing	1
land development	4	inaccessible	1
push-off planting	3	blueberry field	1
replanted	2	gravel pit	1

Table 1 shows the distribution of the assessed plantations by subdivisions. In most cases approximately 25% of the total area planted in a subdivision was sampled. The number of plantations sampled by Group Venture was as follows:

North Mountain	9	Conform	7
West Pictou	5	North Nova	6
Athol	4	La Forét	3
Baddeck	2		

Most of the sampled plantations were softwood cutovers (44%) followed by old field-pasture sites (28%) and mixedwood cutovers (10%). Fire and alder sites comprised 7% and 3% respectively with 8% classified as other or unknown. Over 85% of the plantations sampled were located on well drained sites.

Red pine was the most common species (36% of plantations sampled) followed by red spruce (20%), white spruce (17%), black spruce (15%), Norway

spruce (5%), white pine (4%), tamarack (2%) and jack pine (1%).

PLANTATION STOCKING

The average weighted stocking (area basis) of sampled plantations to commercial softwood species, (planted and natural) was 77% (Figure 3, Appendix 1). On average, only 72% of the plantable sites were stocked with planted seedlings. The survival of planted stock in plantations less than or equal to 1.0 ha, however, was considerably lower than for larger plantations (Figure 3). For example, planted stocking to plantable area was 59% in plantations less than or equal to 1.0 ha in size, as opposed to 72% for plantations greater than 5.0 ha. On the other hand, stocking to natural regeneration was considerably higher in the smaller plantations. This increased the planted plus natural stocking of these smaller plantations to 73%, making it more comparable to the stocking of larger sized plantations. The greater amount of natural regeneration in the smaller plantations is attributed to the close proximity of adjacent seed-bearing stands.

Overall, almost 80% of the plantations were greater than 60% stocked with planted and natural seedlings. Based on plantable area and planted trees only (PPA), 66% of the plantations were greater than 60% stocked (Appendix 2). The average stocking of planted trees (PPA) ranged from 74% in the Western region to 65% in the Central region (Figure 4 and Appendix 3).

Table 1. Number of plantations sampled by region and subdivision.

Region /Subdivision	# of Plantations	Sampled Area (ha)	Total Planted Area 1978-84 (ha)	Planted Area Sampled (%)
EASTERN				
C.B. North	19	50	169	29.6
C.B. South	12	56	219	25.6
Eastern	86	309	1253	24.7
	117	415	1641	25.3
CENTRAL				
N. Central	24	58	619	9.4
S. Central	29	83	321	25.9
	53	141	940	15.0
WESTERN				
S. Shore	12	66	131	50.4
Valley	22	117	343	34.1
Western	10	62	272	22.8
	44	245	746	32.8
TOTALS	214	801	3327	24.1

Stocking showed a downward trend as plantation age increased, although this trend was not strong (Figure 5, Appendix 4). Similarly, stocking was not strongly related to either stock type, or species (Appendix 5). Spruce plantations though, showed higher survival (PPA = 73%) than pine plantations (PPA = 67%). In addition, bareroot plantations showed higher survival (PPA) than multipot plantations (i.e., bareroot spruce plantations had a survival of 76% as opposed to 70% for multipot spruce plantations).

With the exception of sites previously burned by wildfires, site history appeared to have little effect on stocking (Figure 6). On burned sites, stocking (PPA) was 92% compared to 68% for softwood cutovers, 71% for old fields and pastures, and 70%

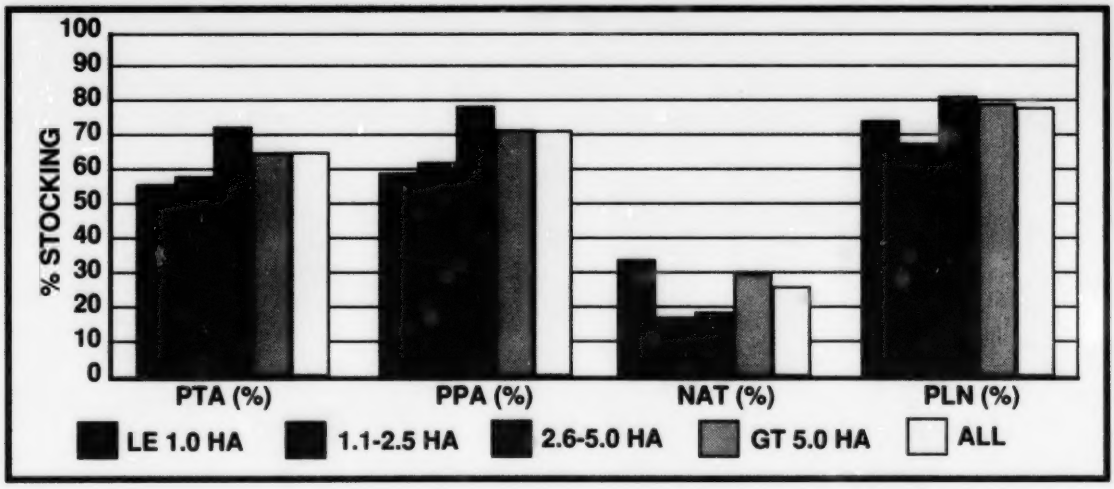

Figure 3. Mean stocking in percent by plantation size. Means weighted by area.
PTA = planted stocking to total area
PPA = planted stocking to plantable area
NAT = natural stocking to total area
PLN = planted plus natural stocking to total area

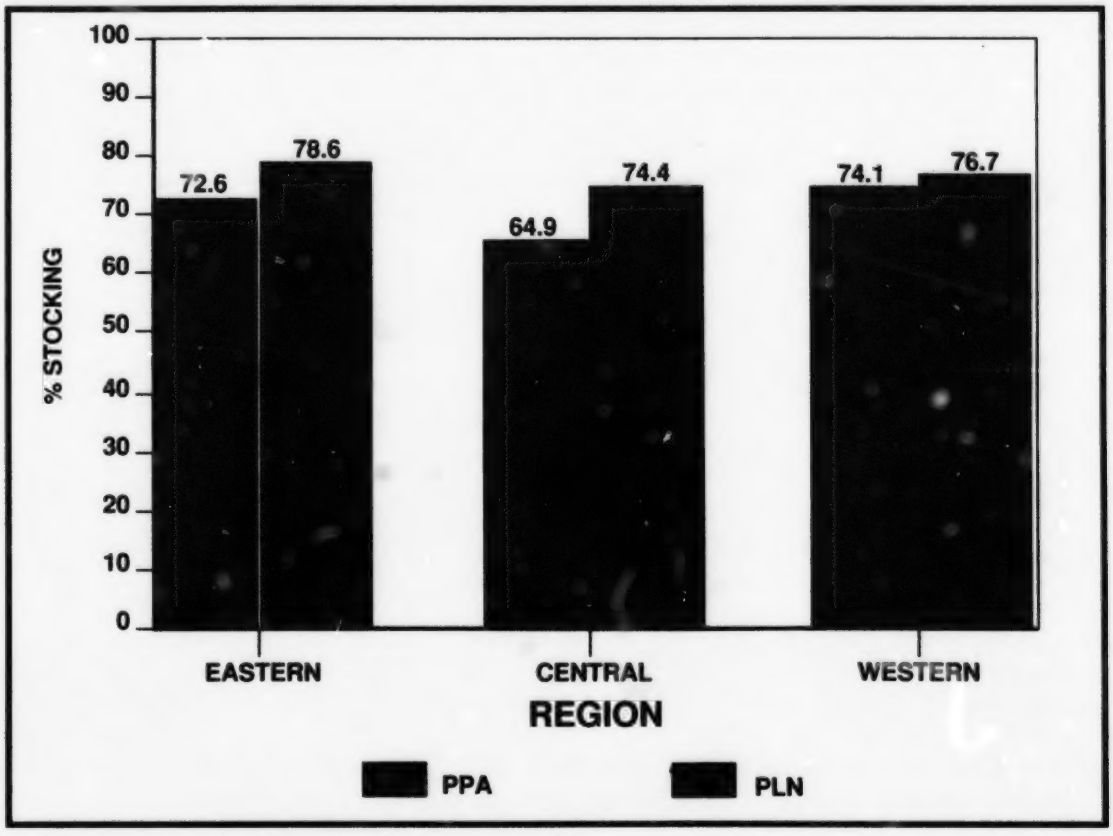

Figure 4. Mean plantation stocking by region (weighted by area).
PPA = planted stocking to plantable area
PLN = planted plus natural stocking to total area

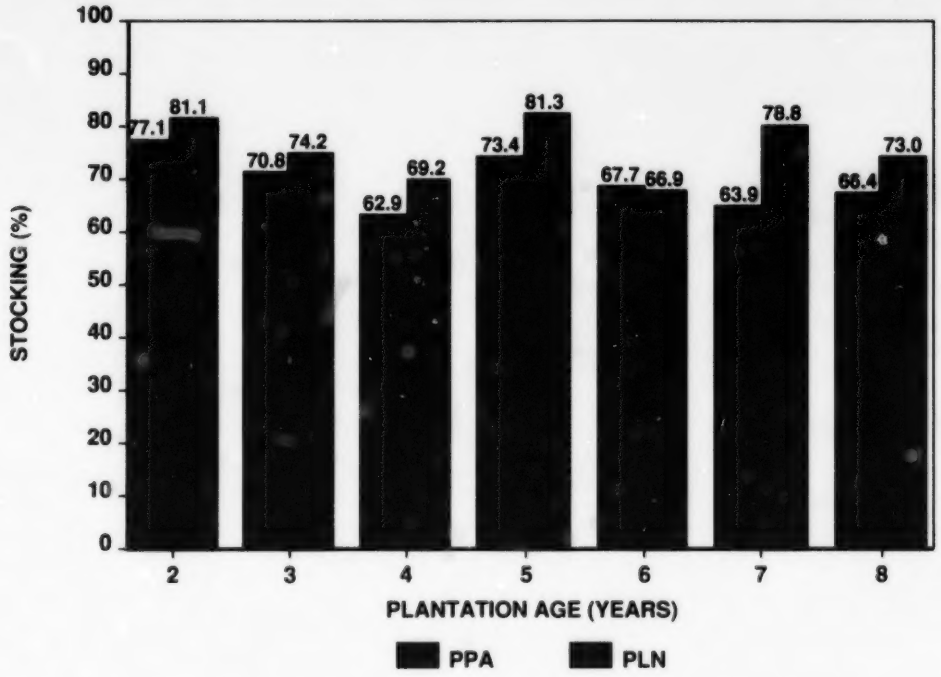

Figure 5. Mean stocking by plantation age (weighted by area), all species and stock types.
PPA = planted stocking to plantable area
PLN = planted plus natural stocking to total area

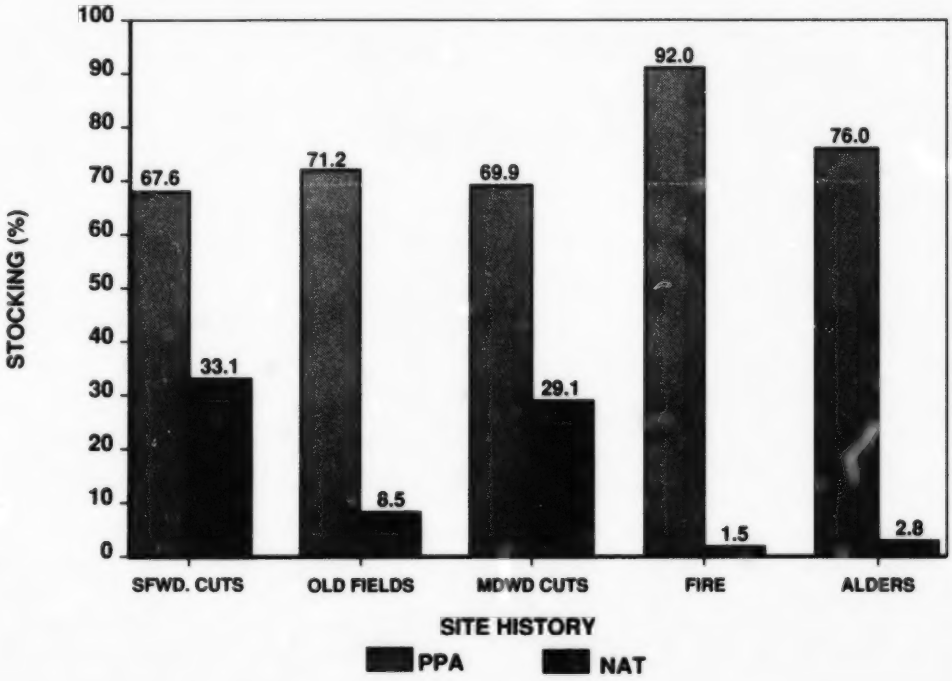

Figure 6. Mean stocking by site history (weighted by area).
PPA = planted stocking to plantable area
NAT = natural stocking to total area

for mixed wood cutovers. The burned sites though, did not have as much natural regeneration as the cutovers and old field sites (burned - 2%, softwood cutover - 33%, mixedwood - 29% and old fields - 9%).

Most plantations were in a healthy condition. Over 70% of the seedlings were recorded as healthy in 84% of the plantations. Poor seedling vigour, where less than 50% of the planted seedlings were described as healthy, occurred in only 6% of the plantations (Appendix 6).

VEGETATIVE COMPETITION

The main species of vegetative competition found in plantations, summarized by occurrence, is as follows:

Grass spp.	51%	Ericaceous spp.	11%
Rubus spp.	45%	Pin cherry	8%
Herbaceous spp.	31%	White Birch	7%
Alder spp.	17%	Willow	4%
Red Maple	15%	Aspen	3%

Grass was the most common species recorded and occurred in over 50% of the plantations. Raspberry was the second most common species (45%) followed by herbaceous vegetation (31%). Weeding of this competition was deemed necessary in 45% of the plantations sampled.

Plantation stocking (both PPA and PLN), leader length and the percent of healthy planted seedlings was inversely related to the percent of planted seedlings being severely competed against (Figure 7 and Appendix 7). For example, mean survival (PPA) was only 48% when 80-100% of the seedlings were severely competed against, whereas it was 76% when only 0-20% of the seedlings were severely competed against. Oxenham (1983) obtained similar results from an experiment designed to determine competition affects on seedling survival and growth. He found mean leader length decreased 57% under severe competition (47% in this study). He also found that increased levels of competition caused mortality to vary from 24 to 56% (24 to 52% in this study). Perala (1982) made

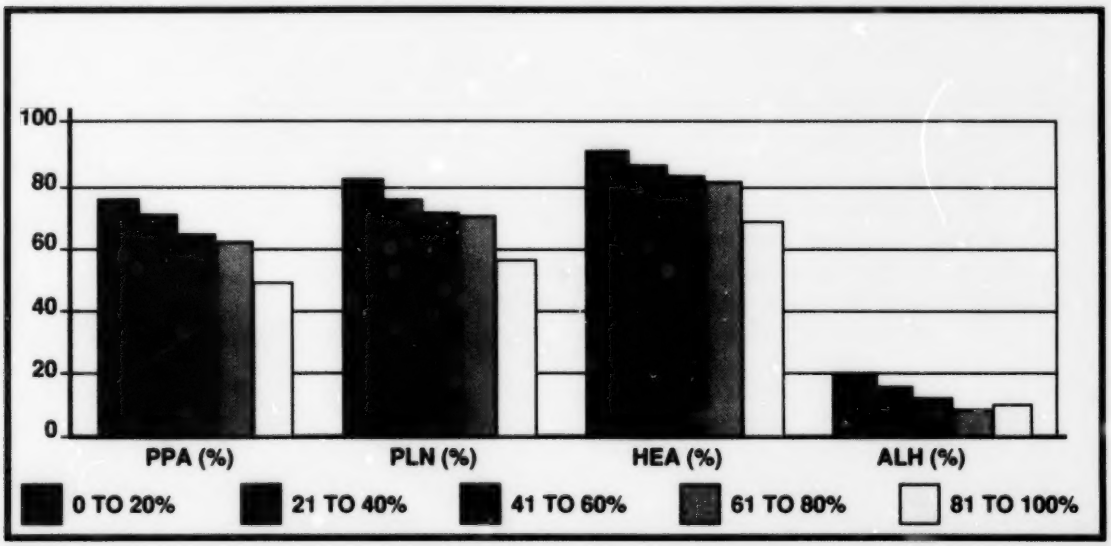

Figure 7. Mean stocking, health and leader length by selected vegetative competition levels (0-20%, 21-40%, 41-60%, 61-80% and 81-100% of planted seedlings severely competed against). All means are weighted by area.
PPA = planted stocking to plantable area
PLN = planted plus natural stocking to total stocking
HEA = percent of planted seedlings in healthy condition
ALH = mean leader length

similar conclusions in a study summarizing the results of experiments in the Upper Great Lakes region. He found that mortality averaged 20% for fully released trees as opposed to 44% for suppressed trees in conifer plantations. His report also indicated that height growth averaged 46% less for suppressed trees.

BROWSING

The level of browsing was determined by assessing the degree of damage to the leader and laterals of each planted seedling in the subplots. Lateral browsing was categorized as light, moderate, severe, or complete. Approximately 50% of all plantations showed no evidence of recent browsing. This indicates that browsing populations were minimal in many parts of the Province during the time of the survey. Considering only those plantations which were browsed, damage was greatest in the smaller sized plantations. These smaller plantations had 36% of their seedlings browsed on average (Appendix 1). Browsing in the larger plantations (5.1 hectares or more) was less intense, affecting 11% of the trees on average.

By examining browsed plantations versus those with no browsing present, it appears that browsed sites have slightly lower survival, health and leader

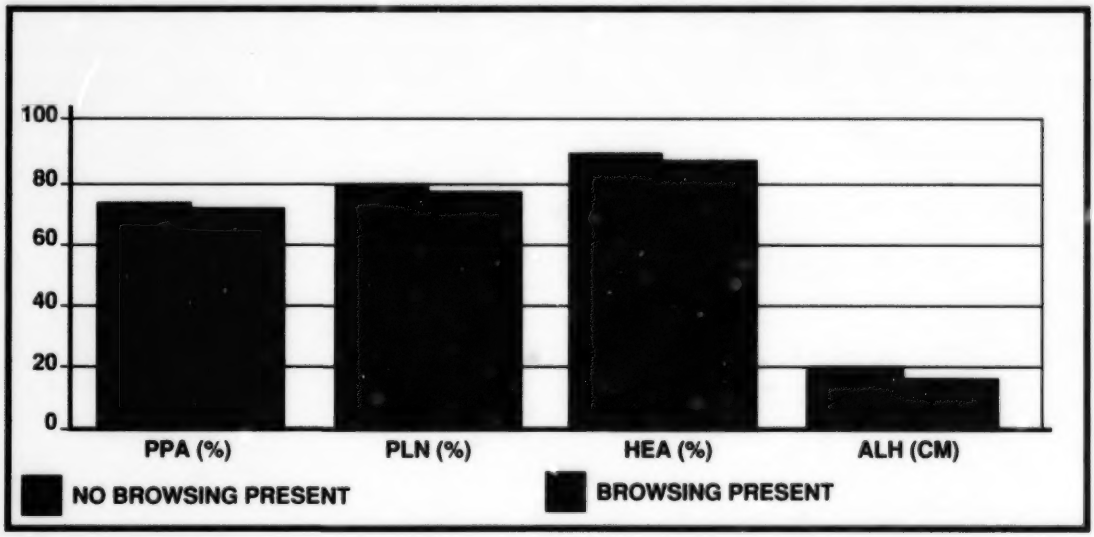

Figure 8. Mean stocking, health and leader growth by presence of browsing. Means are weighted by area. Mean percentage of planted seedlings browsed when browsing present = 16%.
PPA = planted stocking to plantable area
PLN = planted plus natural stocking to total area
HEA = percent of planted seedlings in healthy condition
ALH = mean leader length

lengths (Figure 8, Appendix 7). For example, survival for sites with no browsing evident averaged 73% while it averaged 71% for sites with browsing. It should be noted that on average only 16% of the seedlings were being browsed within the browsed plantations. In addition, it is likely that many of the trees now classified as missing were previously nipped off by deer or rabbits at ground level.

PLANTATION HEIGHT AND LEADER GROWTH

The average height of planted pine exceeded 1.0 metre in height five years after outplanting compared to 0.5 m for spruce (Appendix 8). Bareroot stock outperformed container stock in most instances. For example, five year old bareroot spruce stock averaged 17.6 cm in leader height as opposed to 12.1 cm for container spruce.

Planted seedlings appear to experience a period of adjustment and slow growth after planting (Appendix 8). This lag appears to last four years for pine, judging by the difference in observed leader growth between four year old plantations (13.8 cm) and five year old plantations (26.3 cm).

SITE PREPARATION

Site preparation information was recorded for 66% of the plantations surveyed. Of these plantations, 37% (19% by area) were not site prepared (Appendix 9). Although the number of non-site prepared plantations represents a large proportion of the plantations sampled, nearly 60% of these were "old fields". These non-site prepared plantations represent only 9% of the planted area exclusive of "old fields". Although the total area affected is small, planted stock survival (PPA) was only 54% for plantations that were not site prepared as opposed to 75% (Figure 9, Appendix 10) for plantations that were site prepared (exclusive of "old fields").

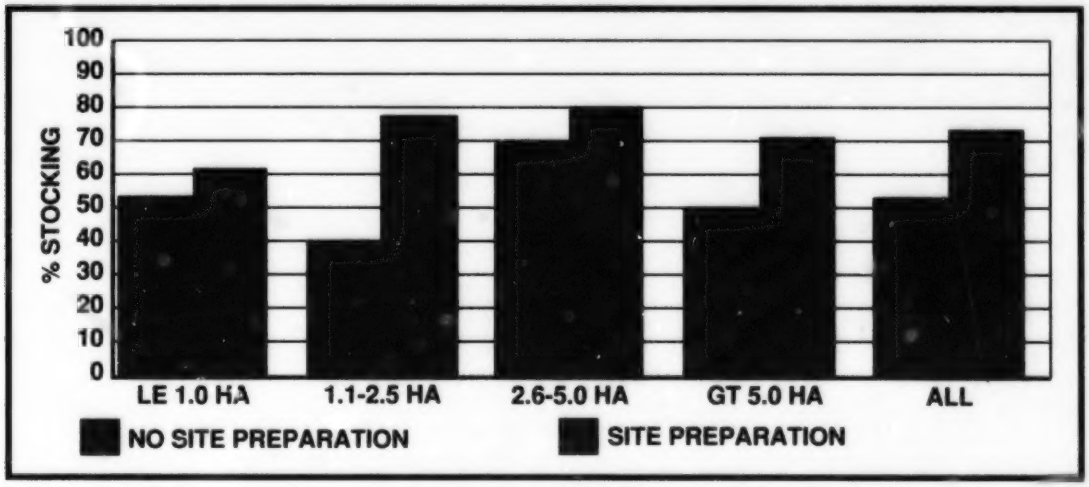

Figure 9. Stocking (PPA, %) of site prepared versus non-site prepared plantations by size excluding old field sites.
PPA = planted stocking to plantable area
ALL = weighted by area

SUMMARY

A summary of the results from the private woodlot plantation survey follows:

1) Average stocking based on planted and natural seedlings (PLN) was 77%.
2) Average stocking based on planted seedlings only (PPA) was 72%.
3) Survival of planted stock was low in plantations less than 1.0 ha in size. However, the higher stocking to natural regeneration (32%) in these plantations counterbalanced the poor survival of planted trees resulting in an acceptable level of stocking (73%).
4) Stocking to natural regeneration was less than 25% in 70% of the plantations and only 10% of the sampled plantations had a natural stocking level greater than 60%. Subsequent surveys in the plantations having a large percentage of natural regeneration will be necessary to determine whether many will die due to natural suppression and/or whether a cleaning will be necessary.
5) The competing vegetation found most frequently in the surveyed plantations was grass, raspberry, and other herbaceous species followed less frequently by alders, red maple, ericaceous species, pin cherry, white birch, willow and aspen.
6) Over 20% of the planted seedlings were undergoing severe competition in over 40% of the plantations surveyed. The competition at these sites resulted in lower survival, health and leader growth. Weeding was deemed necessary in 45% of the plantations surveyed.

7) Evidence of browsing was present in 50% of the plantations at the time of the survey. Although the number of seedlings browsed in these plantations averaged only 16%, slightly lower survival and leader growth occurred.
8) Browsing damage was greatest in the smallest plantations. Nearly 36% of the seedlings were browsed in plantations less than or equal to 1.0 ha in size which showed evidence of browsing. Browsing on the largest plantations, i.e. greater than 5.0 ha was substantially less (11%). Additional browsing could have occurred at these plantations without being detected at survey time. This is due to seedlings being nipped off at ground level by browsing animals and classified later as missing.
9) Site prepared plantations showed higher survival (PPA) than those that were not. Exclusive of old field sites, survival was 75% and 54% respectively for site prepared and non-site prepared plantations.
10) Pine plantations grew faster in height than spruce plantations and averaged 1.06 metres after five years. After seven years, pine averaged 1.30 m compared to .65 m for spruce. The slower than expected height growth of these plantations is attributed to a variety of factors including failure to control vegetative competition on 45% of the sites, browsing animals, frost damage, lack of site preparation, poor planting and/or poor stock.
11) Stocking was not strongly related to plantation age, stock type, species, or site history although burned sites showed better planted seedling survival.
12) Overall, plantation vigour was good. Seventy percent of the seedlings in over 84% of the plantations were noted as healthy.
13) A small percentage of the planted area surveyed, 5% by area, was not sampled for a wide variety of reasons including spot planting, push-off planting, plantations destroyed because of land development, and/or changes in land use.
14) Most of the sites planted were softwood cutovers (44%) followed by old fields and pastures (28%), mixedwood cutovers (10%), areas burned by wildfires (7%) and alder sites (3%).
15) Red pine was the most common species planted (36% of plantations sampled) followed by red spruce (20%), white spruce (17%), black spruce (15%), Norway spruce (5%), white pine (4%), tamarack (2%) and jack pine (1%).

LITERATURE CITED

Oxenham, R. 1983. A study on the effect of competing vegetation and browsing on early plantation performance. Nova Scotia Department of Lands and Forests. Forest Technical Note #5. 6 pp.

Perala, D.A. 1982. Early release - current technology and conifer response. Pg. 396-410 *In* Mroz, G.D. and J.F. Berner, compilers. Artificial regeneration of conifers in the Upper Great Lakes region. Michigan Technological University.

APPENDIX 1

Mean stocking and browsing by plantation size.

Plantation Size (ha)	Number of Plantations Sampled	Total Area Sampled (ha)	Stocking %				% of Plantations with Browsing	% of Seedlings Browsed[2]
			PTA	PPA	NAT	PLN		
1.0 or less	49	33	55.4	58.6	31.9	73.2	44.9	36.0
1.1 - 2.5	58	104	58.8	62.7	15.1	67.1	43.1	27.9
2.6 - 5.0	63	232	72.7	77.8	16.4	80.5	49.2	17.7
5.1 or more	44	432	65.5	71.6	27.0	78.6	65.9	11.0
All	214	801	65.7[1]	71.7[1]	23.1[1]	77.3[1]	50.0	15.2[1]

1 = Weighted by area
2 = Only plantations where browsing occurred
PTA = Planted stock, total area
PPA = Planted stock, plantable area
NAT = Natural softwood regeneration, total area
PLN = Planted plus natural softwood regeneration, total area

APPENDIX 2

Distribution of plantations by stocking class and category.

Stocking	Plantation Frequency (%)			
	PTA	PPA	NAT	PLN
0-20%	7	7	62	4
21-40%	12	8	18	4
41-60%	22	19	10	13
61-80%	28	28	6	28
81-100%	31	38	4	51
	100	100	100	100

PTA = Planted stocking to total area
PPA = Planted stocking to plantable area
NAT = Natural stocking to total area
PLN = Planted plus natural stocking to total area

APPENDIX 3

Number of plantations and average stocking by region and plantation size class.

		Frequency								
		Plantation Size (ha)				Stocking PPA			Stocking %	
Region	Sample Size	<1.0	1.1-2.5	2.6-5.0	5.1+	<60%	61-80%	81%+	PPA*	PLN*
Eastern	117	34	25	36	22	41	28	48	72.6	78.6
Central	53	10	23	13	7	21	18	14	64.9	74.4
Western	44	5	10	14	15	10	14	20	74.1	76.7

* = Weighted by area
PPA = Planted stocking to plantable area
PLN = Planted plus natural stocking to total area

APPENDIX 4

Mean stocking of sampled plantations by plantation age. Stocking weighted by area.

	Stocking %				
Age	PTA	PPA	NAT	PLN	N
2	71.6	77.1	20.2	81.1	46
3	62.5	70.8	26.2	74.2	45
4	56.6	62.9	21.4	69.2	23
5	68.7	73.4	26.7	81.3	38
6	57.2	67.7	18.0	66.9	29
7	60.2	63.9	28.8	78.8	19
8	65.0	66.4	13.6	73.0	7
All	64.9	71.0	23.5	77.3	207

PTA = Planted stocking to total area
PPA = Planted stocking to plantable area
NAT = Natural stocking to total area
PLN = Planted plus natural stocking to total area
N = Number of plantations

APPENDIX 5

Mean stocking by species and container type. Means weighted by area.

	PPA (%)	Number of Plantations
PINE	67.4	49
Bareroot	71.4	48
Multipot	35.1	1
SPRUCE	72.6	84
Bareroot	75.5	57
Multipot	69.8	25

PPA = Planted stocking to plantable area

APPENDIX 6

The number of plantations with a specified percentage of healthy planted seedlings.

% of Seedlings Healthy	# of Plantations	%	Cumulative %
0-10	3	1.4	1.4
11-20	1	0.5	1.9
21-30	1	0.5	2.4
31-40	2	0.9	3.3
41-50	5	2.3	5.6
51-60	7	3.3	8.9
61-70	15	7.0	15.9
71-80	25	11.7	27.6
81-90	39	18.2	45.8
91-100	116	54.2	100.0
All	214	100	

APPENDIX 7

Mean stocking (PPA & PLN), health, leader length and the number of plantations by occurrence of browsing and levels of severe competition. Means weighted by area.

			% of Seedlings Under Severe Competition				
	Browsing	No Browsing	0-20	21-40	41-60	61-80	81-100
PPA (%)	70.8	72.9	76.3	71.6	64.6	62.0	48.0
PLN (%)	75.9	79.1	81.8	75.9	71.8	70.6	55.0
HEA (%)	86.6	88.8	91.0	86.3	82.8	81.2	69.0
ALH (CM)	15.2	18.3	19.3	16.2	12.5	8.4	10.2
N	107	107	128	29	30	16	11
(%)	(50)	(50)	(59.8)	(13.6)	(14.0)	(7.5)	(5.1)

PPA = Planted stocking to plantable area
PLN = Planted plus natural stocking to total area
HEA = Percent of planted seedlings in healthy condition
ALH = Mean leader length
N = Number of plantations

APPENDIX 8

Mean height and leader growth by species, stock type and plantation age.

Plantation height (m)

			Spruce				Pine	
Age	Average	N	Bareroot	N	Container	N	Bareroot	N
2	.40	46	.34	14	.36	10	.60	5
3	.54	45	.38	15	.32	4	.84	10
4	.47	23	.43	6	.37	6	.45	2
5	.75	38	.51	14	.48	4	1.06	8
6	.89	29	.75	2	.55	2	1.00	13
7	1.18	19	.65	2	-	-	1.30	8
8	1.08	7	.30	2	.60	1	1.90	1
		207		55		27		47

Leader growth (cm)

			Spruce				Pine	
Age	Average	N	Bareroot	N	Container	N	Bareroot	N
2	10.9	46	10.1	14	9.2	10	17.8	5
3	14.4	45	7.9	15	10.0	4	18.7	10
4	13.2	23	10.1	6	9.9	6	13.8	2
5	20.8	38	17.6	14	12.1	4	26.3	8
6	22.0	39	13.2	2	10.5	2	24.9	13
7	23.3	19	10.5	2	-	-	27.7	8
8	22.2	7	11.5	2	12.0	1	34.0	1
		207		55		27		47

N = Sample size

APPENDIX 9

Number and area of plantations by site preparation method.

Method	# (%)	Area (ha) (%)
No Site Preparation	53 (37.3)[1]	97 (18.7)[1]
Site Prepared	89 (62.6)[1]	423 (81.3)[1]
(All Methods)		
Rakes	42 (47.2)[2]	218 (51.3)[2]
Rome Disc	23 (25.8)[2]	105 (24.7)[2]
Plows	9 (10.1)[2]	59 (13.9)[2]
Rollers & Crushers	9 (10.1)[2]	29 (6.8)[2]
Manual	3 (3.4)[2]	3 (0.7)[2]
Hydro-Axe	2 (2.2)[2]	10 (2.4)[2]
Chemical	1 (1.1)[2]	1 (0.2)[2]
No Information	72 (33.6)[3]	281 (35.1)[3]
All Plantations	214	801

1. % of those plantations where site preparation information was recorded
2. % of plantations where site preparation was performed and recorded
3. % of all plantations surveyed

APPENDIX 10

Survival (PPA) in site prepared versus non-site prepared plantations by size excluding old field sites.

Plantation Size (ha)	PPA, % (#)	
	No Site Preparation	Site Preparation
1.0 or less	54.0 (9)	62.5 (10)
1.1 - 2.5	39.9 (6)	78.6 (15)
2.6 - 5.0	70.2 (5)	80.5 (25)
5.1 or more	49.4 (1)	71.7 (25)
All	53.6 (21)*	74.8 (75)*

PPA = Planted stocking to plantable area
* = Weighted by area

FOREST RESEARCH SECTION
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N.S. DEPT. OF LANDS AND FORESTS

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